3. Methane Emissions

Overview

U.S. Anthropogenic Methane Emissions, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	26.6	612.8
Change Compared to 2001 (Million Metric Tons)	-0.8	-17.3
Change from 2001 *(Percent)*	*-2.7%*	*-2.7%*
Change Compared to 1990 (Million Metric Tons)	-4.6	-106.3
Change from 1990 *(Percent)*	*-14.8%*	*-14.8%*

U.S. anthropogenic methane emissions totaled 26.6 million metric tons of methane (612.8 million metric tons carbon dioxide equivalent)[53] in 2002, a decrease of 0.8 million metric tons of methane from 2001 levels (Table 13). The decline in total methane emissions was primarily the result of a 0.6 million metric ton decrease in methane emissions from landfills, as well as smaller decreases in emissions from coal mining and stationary combustion. The amount of methane generated from the decomposition of waste in landfills was nearly unchanged between 2001 and 2002, but a 0.6 million metric ton increase in methane recovered for energy reduced net emissions from this source substantially. In addition, U.S. coal production dropped by 3.0 percent.

Estimated U.S. emissions of methane in 2002 were 4.6 million metric tons below the 1990 level, a decrease equivalent to 106.3 million metric tons of carbon dioxide, or 1.5 percent of total U.S. anthropogenic greenhouse gas emissions. In addition to a 4.1 million metric ton decrease in methane emissions from landfills since 1990, there was also a 1.4 million metric ton decrease in methane emissions from coal mines during the same period (Table 14). The 32.8-percent decline in emissions from coal mining was the result of a 207.3 percent increase in methane recovery from coal mines and a shift in production away from gassy mines. Overall, methane emissions account for about 8.9 percent of total U.S. greenhouse gas emissions when weighted by methane's global warming potential factor.

As a result of revisions in estimation methods for emissions from enteric fermentation and the solid waste of domesticated animals, overall estimated levels of methane emissions in this report are lower than the estimates previously published by the Energy Information Administration (EIA). The downward revision amounts to approximately 0.7 million metric tons in 1990 and 1.2 million metric tons in 2001.

Methane emission estimates are much more uncertain than carbon dioxide emission estimates. Methane emissions usually are accidental or incidental to biological processes and may not be metered in any systematic way.[54] Thus, methane emission estimates must often rely on proxy measurements.

Estimated U.S. anthropogenic methane emissions for 2002 are based on incomplete data for several key sources; thus, the overall estimate is likely to be revised. Emissions from three of these sources—coal mining, natural gas systems, and landfills—represented three-fifths of all U.S. methane emissions. Thus, comparisons between 2001 and 2002 numbers are more likely to be valid in the context of directional change rather than magnitude of change. For example, because 2002 data on waste generation are not yet available, waste generation has been scaled to economic output as a proxy. Less critical but still important data are also unavailable for natural gas systems, such as miles of gas transmission and distribution pipeline.

[53] Based on an estimated global warming potential factor of 23 for methane. For an expanded discussion of global warming potentials, see the Executive Summary, p. xiii.

[54] Wherever possible, estimates of methane emissions are based on measured data. In some cases, however, measured data are incomplete or unavailable. In the absence of measured data, emissions are indexed to some known activity data, such as coal production or natural gas throughput, and multiplied by an emissions factor derived from a small sample of the relevant emissions source or through laboratory experiments. For a more detailed discussion of where measured data were used and how emissions factors were developed, see Energy Information Administration, *Documentation: Emissions of Greenhouse Gases in the United States 2002* (to be published). The absence of measured emissions data for most sources of methane emissions and the reliance on emissions factors represent a source of uncertainty (further details are available in Energy Information Administration, *Documentation: Emissions of Greenhouse Gases in the United States 2002* (to be published).

Principal Sources of U.S. Anthropogenic Methane Emissions, 1990-2002

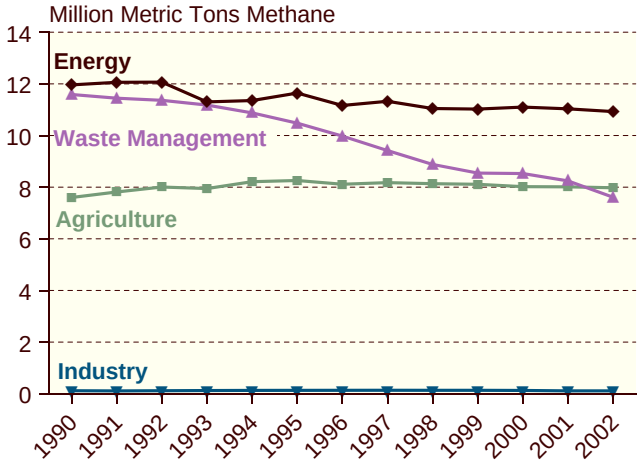
Source	Million Metric Tons Methane 1990	2002	Percent Change 1990-2002	2001-2002
Energy	11.96	10.95	*-8.5%*	*-0.7%*
Waste Management	11.59	7.61	*-34.3%*	*-7.7%*
Agriculture	7.60	7.98	*5.0%*	*-0.5%*
Industrial Processes	0.12	0.11	*-4.4%*	*-0.4%*

Energy Sources

U.S. methane emissions from energy sources were estimated at 10.9 million metric tons in 2002 (251.8 million metric tons carbon dioxide equivalent), 0.1 million metric tons lower than 2001 levels and 1.0 million metric tons below 1990 levels (Figure 3). The drop in methane emissions from energy sources since 1990 can be traced primarily to decreased emissions from coal mines and, to a lesser extent, to lower emissions from petroleum systems and stationary combustion.

Methane emissions from coal mines dropped by 32.8 percent (1.4 million metric tons) between 1990 and 2002. This decline resulted from the increased capture and use of methane from coal mine degasification systems and a shift in production away from some of the Nation's gassiest underground mines in Central Appalachia.

Figure 3. U.S. Emissions of Methane by Source, 1990-2002



Source: Estimates presented in this chapter.

Between 1990 and 2002, the share of coal production represented by underground mines declined from 41.2 percent to 31.9 percent. Methane emissions from petroleum systems dropped from 1.3 million metric tons in 1990 to 1.0 million metric tons in 2002. A decrease of 0.2 million metric tons in estimated methane emissions from stationary combustion made a smaller contribution to the overall drop in emissions from energy sources between 1990 and 2002. Together, the declines in emissions from coal mining and stationary combustion more than compensated for the increase of 0.9 million metric tons in emissions from the natural gas system, attributed to increasing U.S. consumption of natural gas between 1990 and 2002.

Coal Mining

U.S. Methane Emissions from Coal Mining, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	2.9	65.7
Change Compared to 2001 (Million Metric Tons)	-0.1	-2.4
Change from 2001 *(Percent)*	*-3.6%*	*-3.6%*
Change Compared to 1990 (Million Metric Tons)	-1.4	-32.0
Change from 1990 *(Percent)*	*-32.8%*	*-32.8%*

The preliminary estimate of methane emissions from coal mines for 2002 is 2.9 million metric tons (Table 14), a decrease of 3.6 percent from the 2001 level.[55] This decrease can be traced to declines in coal production levels, which dropped by 3.0 percent in 2002 after rising by 5.0 percent in 2001.

U.S. coal production declined to 1.09 billion short tons in 2002, down from the record 2001 level of 1.13 billion short tons. The decline was primarily the result of a decrease in coal exports and high levels of coal stocks built up during 2001. Annual U.S. coal consumption was nearly constant between 2001 and 2002. Between 1990 and 2002, methane emissions from coal mines dropped by 32.8 percent from the 1990 level of 4.2 million metric tons. The decline is attributed to three important trends: (1) methane recovery from active coal mines for use as an energy resource increased from 0.3 million metric

[55]Further details on emissions from abandoned coal mines are available in Energy Information Administration, *Documentation: Emissions of Greenhouse Gases in the United States 2002* (to be published).

tons in 1990 to about 0.8 million metric tons in 2002; (2) methane drainage from degasification in active mines decreased by more than 0.2 million metric tons between 1990 and 2002; and (3) methane emissions from ventilation systems at gassy mines dropped by about 0.6 million metric tons between 1990 and 2002 (Table 14).[56]

Natural Gas Systems

U.S. Methane Emissions from Natural Gas Systems, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	6.5	148.9
Change Compared to 2001 (Million Metric Tons)	0.1	2.0
Change from 2001 *(Percent)*	*1.4%*	*1.4%*
Change Compared to 1990 (Million Metric Tons)	0.9	19.9
Change from 1990 *(Percent)*	*15.5%*	*15.5%*

At 6.5 million metric tons, 2002 estimated methane emissions from natural gas production, processing, and distribution were up from the revised estimate of 6.4 million metric tons for 2001 (Table 15). The 1.4-percent increase in emissions can be traced to an increase in gas withdrawals from storage in 2002; however, the 2002 estimate is preliminary, because pipeline data for 2002 had not been finalized as of the publication of this report. The estimated 2002 emissions level is 15.5 percent above the 1990 level, with about two-thirds of the increase attributable to increased mileage of distribution pipelines and one-third attributable to increases in gas withdrawals.[57]

Petroleum Systems

Methane emissions from petroleum systems are estimated at 1.0 million metric tons in 2002, nearly unchanged from 2001 levels and down by 21.5 percent from 1.3 million metric tons in 1990. Domestic oil production in 2002 was 78.1 percent of the 1990 level, accounting for the decline in methane emissions from this source. Approximately 96.4 percent of all emissions from petroleum systems occur during exploration and production. Of the roughly 1.0 million metric tons of methane emissions annually from this source, 90.3 percent was traced to venting, of which nearly half is attributable to venting from oil tanks (Table 16). A much smaller portion of methane emissions from petroleum systems can be traced to refineries and transportation of crude oil.

U.S. Methane Emissions from Petroleum Systems, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	1.0	23.5
Change Compared to 2001 (Million Metric Tons)	*	-0.2
Change from 2001 *(Percent)*	*-1.0%*	*-1.0%*
Change Compared to 1990 (Million Metric Tons)	-0.3	-6.4
Change from 1990 *(Percent)*	*-21.5%*	*-21.5%*

*Less than 0.05 million metric tons.

Stationary Combustion

U.S. methane emissions from stationary combustion in 2002 were 0.4 million metric tons, down by 12.3 percent from the 2001 level and 36.0 percent below 1990 levels (Table 17). Residential wood consumption typically accounts for about 85 percent of methane emissions from stationary combustion. Methane emissions are the result of incomplete combustion, and residential woodstoves and fireplaces provide much less efficient combustion than industrial or utility boilers. Estimates of residential wood combustion are, however, very uncertain (for further details, see Energy Information Administration, *Documentation: Emissions of Greenhouse Gases in the United States 2002* (to be published). The universe of wood consumers is large and heterogeneous, and EIA collects data on residential wood consumption only at 4-year intervals in its Residential Energy Consumption Survey (RECS). The most recently published EIA data on residential wood consumption are from the

[56]The EPA believes that a significant portion of methane recovery from coal mines should not be deducted from current-year emissions, because the gas is being drained from coal seams that will be mined only in future years, if at all. The relationship between estimates of emissions from degasification and estimates of gas recovery is under review and may be revised in the future.

[57]The EPA estimates that the companies participating in the Natural Gas STAR program together avoided emissions of 822,000 metric tons of methane in 2001 and 960,000 metric tons in 2002. Program participants report annually on emissions reductions achieved through such activities as equipment replacement, enhanced inspection and maintenance, and improved operations management. Participating companies may either use their own techniques to estimate reductions achieved or employ default values developed by the EPA and the Gas Technology Institute (formerly the Gas Research Institute).

U.S. Methane Emissions from Stationary Combustion, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	0.4	8.3
Change Compared to 2001 (Million Metric Tons)	-0.1	-1.2
Change from 2001 *(Percent)*	*-12.3%*	*-12.3%*
Change Compared to 1990 (Million Metric Tons)	-0.2	-4.7
Change from 1990 *(Percent)*	*-36.0%*	*-36.0%*

1997 RECS. Updated data on residential wood consumption for calendar year 2002 will be available from the 2003 RECS.

Mobile Combustion

U.S. Methane Emissions from Mobile Sources, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	0.2	5.5
Change Compared to 2001 (Million Metric Tons)	*	-0.1
Change from 2001 *(Percent)*	*-1.0%*	*-1.0%*
Change Compared to 1990 (Million Metric Tons)	*	-0.1
Change from 1990 *(Percent)*	*-2.3%*	*-2.3%*

*Less than 0.05 million metric tons.

Estimated U.S. methane emissions from mobile combustion in 2002 were 0.2 million metric tons, down by 1.0 percent from 2001 levels and 2.3 percent lower than the 1990 level (Table 18). Methane emissions from passenger cars have declined since 1990 as older cars with catalytic converters that are less efficient at destroying methane have been taken off the road. However, from 1993 to 1999, rapid growth in the fleet of light-duty trucks and the related increase in methane emissions offset the declines from passenger cars. Since 1999, as growth in the fleet of light-duty trucks has moderated and the penetration of advanced catalytic converters has grown, emissions from both passenger cars and light-duty trucks have declined.

Waste Management

Methane emissions from waste management accounted for 28.6 percent of U.S. anthropogenic methane emissions in 2002 (Figure 3), down from 37.1 percent in 1990. Landfills represent 91.2 percent of the 7.6 million metric tons of methane emissions from waste management and remain the single largest source of U.S. anthropogenic methane emissions (Table 13). The remainder of emissions from waste management is associated with domestic wastewater treatment. Estimated emissions from waste management would increase if sufficient information were available to develop a reliable estimate of emissions from industrial landfills and industrial wastewater treatment. The U.S. Environmental Protection Agency (EPA) estimates some 1.7 million metric tons of methane emissions from these two sources during 2001 (1.0 million metric tons from industrial landfills and 0.7 million metric tons from wastewater treatment), or about 6.3 percent of total estimated U.S. methane emissions.[58]

Landfills

Due to record levels of methane recovery for energy at U.S. landfills,[59] estimated methane emissions from landfills dropped to 6.9 million metric tons (159.7 million metric tons carbon dioxide equivalent) in 2002, 8.5 percent below the 2001 level of 7.6 million metric tons and 4.1 million metric tons (37.0 percent) below 1990 levels (Table 19). The dramatic decrease in methane emissions since 1990 is directly attributable to a 4.7 million metric ton increase in methane captured that otherwise would have been emitted to the atmosphere. Of the 5.9 million metric tons of methane believed to be captured from this source in 2002, 3.0 million metric tons was recovered for energy use, and 2.9 million metric tons was recovered and flared. In 2002, methane recovery for energy increasingly took the form of direct use of medium-Btu gas in industrial boilers. The acceleration of this practice was driven by higher natural gas prices, which made landfill gas more competitive.[60]

[58] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2001*, EPA-430-R-03-004 (Washington, DC, April 2003), web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html.

[59] U.S. Environmental Protection Agency, Landfill Methane Outreach Program, web site www.epa.gov/lmop.

[60] Personal communication with Brian Gozzone, U.S. Environmental Protection Agency, Landfill Methane Outreach Program.

U.S. Methane Emissions from Landfills, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	6.9	159.7
Change Compared to 2001 (Million Metric Tons)	-0.6	-14.8
Change from 2001 *(Percent)*	*-8.5%*	*-8.5%*
Change Compared to 1990 (Million Metric Tons)	-4.1	-93.6
Change from 1990 *(Percent)*	*-37.0%*	*-37.0%*

While estimates of methane recovered and disposed of both by flaring and by recovery for energy are drawn from data collected by the EPA's Landfill Methane Outreach Program,[61] there is less uncertainty in the estimate of methane recovered and used for energy. It is likely that estimates of methane flared are biased downward due to a lack of comprehensive industry data.

The rapid growth in methane recovery has been aided by a combination of regulatory and tax policy. The Federal Section 29 (of the Internal Revenue Code) tax credit for alternative energy sources, added to the tax code as part of the Crude Oil Windfall Profits Act of 1980, provided a subsidy roughly equivalent to 1 cent per kilowatthour for electricity generated from landfill gas. However, this tax credit expired on June 30, 1998, and, absent a similar subsidy, the number of additional landfill gas-to-energy projects that are commercially viable may be limited.

H.R. 6, the comprehensive energy bill before the U.S. Senate in September 2003, contains new landfill gas-to-energy incentives under Section 45 of the Internal Revenue Code that would run through 2007. Increases in methane recovery have also resulted from the implementation of the EPA's New Source Performance Standards and Emission Guidelines. These regulations require all landfills with more than 2.5 million metric tons of waste in place and annual emissions of nonmethane volatile organic compounds (NMVOCs) exceeding 50 metric tons to collect and burn their landfill gas, either by flaring or for use as an energy source.

Domestic and Commercial Wastewater Treatment

U.S. Methane Emissions from Domestic and Commercial Wastewater Treatment, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	0.7	15.3
Change Compared to 2001 (Million Metric Tons)	*	0.2
Change from 2001 *(Percent)*	*1.3%*	*1.3%*
Change Compared to 1990 (Million Metric Tons)	0.1	2.1
Change from 1990 *(Percent)*	*15.6%*	*15.6%*

*Less than 0.05 million metric tons.

With the U.S. population growing slowly, methane emissions from domestic and commercial wastewater treatment are estimated to have grown by 1.3 percent between 2001 and 2002 to 0.67 million metric tons. This is about 15.6 percent above the 1990 level of 0.58 million metric tons (Table 13). Methane emissions from industrial wastewater treatment are discussed in the box on page 38.

EIA has revised the estimates of methane emissions from domestic and commercial wastewater since publication of the previous edition of this inventory, *Emissions of Greenhouse Gases in the United States 2001*. Estimates of the fraction of organic content in wastewater and the portion of wastewater that decays anaerobically have been increased.[62] The resulting estimates show annual emissions nearly four times as large as those previously published.

Methane emissions from domestic and commercial wastewater treatment are a function of the share of organic matter in the wastewater stream and the conditions under which it decomposes. Wastewater may be treated aerobically or anaerobically. Because aerobic decomposition does not yield methane, whereas anaerobic decomposition does, the method of treatment is a critical determinant of emissions; however, there is little information available on wastewater treatment methods. Data on flaring or energy recovery from methane

[61] U.S. Environmental Protection Agency, Landfill Methane Outreach Program, web site www.epa.gov/lmop.

[62] For detailed discussion of the methods employed, see Energy Information Administration, *Documentation: Emissions of Greenhouse Gases in the United States 2002* (to be published).

Methane Emissions from Industrial Wastewater Treatment

Industries generating high volumes of wastewater that includes large amounts of organic material are likely to generate methane emissions from the anaerobic decomposition of that organic material. Industries that fit this description include pulp and paper manufacturing, meat and poultry packing, and vegetable, fruit and juice processing. Determining total wastewater outflows, organic loadings, and the portion of anaerobic degradation of the loadings for each industry is difficult. Further, the emissions contribution of other industries is impossible to quantify at this time. Thus, EIA has chosen to exclude this emissions source from its estimates of overall methane emissions.

In its report, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*, the U.S. Environmental Protection Agency (EPA), makes some assumptions about the level of anaerobic decomposition of organic wastes in wastewater for the three industries referenced above.[a] For those three industries, the EPA estimates 900,000 metric tons of methane emissions in 2001, an amount equal to EIA's current estimate of methane emissions from wastewater treatment and equivalent to 2.5 percent of total estimated U.S. methane emissions.

[a]U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2001*, EPA-430-R-03-004 (Washington, DC, April 2003), web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html.

generated by wastewater are also sparse. EIA believes that emissions from this source are relatively small, representing 2.5 percent of all U.S. methane emissions in 2002. Thus, emissions are estimated using a default per-capita emissions factor and U.S. population data.

Agricultural Sources

Estimated agricultural methane emissions decreased by 0.5 percent between 2001 and 2002 due mainly to small decreases in emissions from animal waste and rice cultivation. At an estimated 8.0 million metric tons of methane (183.4 million metric tons carbon dioxide equivalent), methane emissions from agricultural activities in 2002 represent 29.9 percent of total U.S. anthropogenic methane emissions (Table 13). Ninety-four percent of methane emissions from agricultural activities result from livestock management. Sixty-seven percent of these emissions can be traced to enteric fermentation in ruminant animals, and the remainder is attributable to the anaerobic decomposition of livestock wastes. A small portion of U.S. methane emissions result from crop residue burning and wetland rice cultivation.

Revisions to the estimation methods for enteric fermentation and the solid waste of domesticated livestock have lowered EIA's estimates of methane emissions from agriculture for 1990 by approximately 0.7 million metric tons and for 2001 by 1.2 million metric tons. Aside from the magnitude of the change, the most noticeable effect of the revised methods was to alter the trend line in emissions from enteric fermentation. Rather than increasing slowly between 1996 and 2000, emissions from this source are now estimated to have declined slightly during that period.

Enteric Fermentation in Domesticated Animals

U.S. Methane Emissions from Enteric Fermentation in Domesticated Animals, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	5.0	115.1
Change Compared to 2001 (Million Metric Tons)	*	*
Change from 2001 *(Percent)*	*	*
Change Compared to 1990 (Million Metric Tons)	-0.2	-4.9
Change from 1990 *(Percent)*	*-4.1%*	*-4.1%*

*Less than 0.05 million metric tons or less than 0.05 percent.

In 2002, estimated methane emissions from enteric fermentation in domesticated animals were unchanged from the 2001 level of 5.0 million metric tons (Table 20). Because cattle account for 95.1 percent of all emissions from enteric fermentation, trends in emissions correlate with trends in cattle populations. Between 2001 and 2002, cattle populations were nearly constant, with small declines in beef cattle populations offset by small increases in dairy cattle populations. Estimated methane emissions from enteric fermentation in 2002 are 4.1 percent below 1990 levels.

The animal population data and methodologies used to estimate methane emissions from enteric fermentation have been revised for the 2002 inventory, affecting the estimates for all years. The revised population estimates eliminate previous double counting of beef cattle in feedlots, in turn reducing emissions from enteric fermentation in beef cattle for 1990 through 2002. In addition, the adjusted methane emissions factors reflect greater detail that the EPA has incorporated into the Tier 2 methodology outlined in the "good practice guidance" of the Intergovernmental Panel on Climate Change.[63] Together, these changes alter the estimated trend in emissions from this source. Using both the old and new methods, estimated emissions from enteric fermentation emissions peaked in 1995; however, previously published estimates showed emissions largely flat between 1996 and 2001, whereas the new methods show a decrease in emissions since 1996.

Solid Waste of Domesticated Animals

U.S. Methane Emissions from Solid Waste of Domesticated Animals, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	2.5	56.8
Change Compared to 2001 (Million Metric Tons)	*	-0.5
Change from 2001 *(Percent)*	*-0.9%*	*-0.9%*
Change Compared to 1990 (Million Metric Tons)	0.5	12.3
Change from 1990 *(Percent)*	*27.6%*	*27.6%*

*Less than 0.05 million metric tons.

Estimated methane emissions from the solid waste of domesticated animals decreased from 2.49 million metric tons in 2001 to 2.47 million metric tons in 2002 (Table 21). This small drop was the result of decreases in beef cattle and swine populations. The drop offset a larger trend over the past decade: in 2002, emissions from the solid waste of domesticated animals were 0.5 million metric tons above 1990 levels, an increase of 27.6 percent. Between 1990 and 2002 there was a shift of swine populations to larger livestock operations, which are believed to be more likely to manage waste using liquid systems that tend to promote methane generation.[64] To capture this shift and other trends in the management of the solid waste of domesticated animals, EIA revised its estimation methods for this source. The typical animal mass was revised for all animal categories, including revisions to swine sizes to conform more closely with USDA classifications. In addition, EIA has updated volatile solids factors and altered the distribution of waste management systems to reflect the general shift to larger, more managed farms. Together, these changes lowered annual estimates of methane emissions from the solid waste of animals by about 0.6 million metric tons.

Rice Cultivation

Estimated methane emissions from U.S. rice cultivation declined to 0.46 million metric tons in 2002 from 0.47 million metric tons in 2001. The drop was the result of a 3.3-percent decrease in the number of acres harvested. Arkansas, Missouri, Louisiana, and Texas all saw decreases in acres harvested. Methane emissions from rice cultivation in 2002 were 13.4 percent higher than in 1990 (Table 13).

Burning of Crop Residues

Crop residue burning, the smallest contributor to agricultural greenhouse gas emissions, represents less than 0.2 percent of total U.S. methane emissions. Estimated 2002 methane emissions from the burning of crop residues were 0.05 million metric tons, down by 4.7 percent from 2001 levels but still 3.0 percent above 1990 levels (Table 13). The small decrease is attributable mainly to declines in corn, sorghum, barley, wheat, and soybean production.

Industrial Sources

Chemical Production

The preliminary estimate of methane emissions from U.S. chemical production in 2002 is 65.6 thousand metric tons, 2.1 percent more than in 2001. The increase is attributable to increased production of carbon black, ethylene, and styrene, more than offsetting a drop in methanol production. Methane emissions from chemical production in 2002 were 18.1 percent above their level in 1990 (Table 22).

[63]IPCC National Greenhouse Gas Inventories Programme, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (J. Penman, D. Kruger, et al., editors) (Tokyo, Japan: Institute for Global Environmental Strategies, 2000), Chapter 4, "Agriculture," web site www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm.

[64]U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1999*, EPA-236-R-01-001 (Washington, DC, April 2001), p. 5-6, web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2001.html.

U.S. Methane Emissions from Industrial Sources, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	0.1	2.6
Change Compared to 2001 (Million Metric Tons)	*	*
Change from 2001 *(Percent)*	*-0.4%*	*-0.4%*
Change Compared to 1990 (Million Metric Tons)	*	-0.1
Change from 1990 *(Percent)*	*-4.4%*	*-4.4%*

*Less than 0.05 million metric tons.

Iron and Steel Production

With production of pig iron and sinter dropping, methane emissions from iron and steel production fell by 3.6 percent between 2001 and 2002, to the lowest levels in more than 20 years. Emissions in 2002, at 46.5 thousand metric tons, were 24.7 percent below the 1990 level of 61.7 thousand metric tons (Table 22).

Table 13. U.S. Methane Emissions from Anthropogenic Sources, 1990-2002

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Million Metric Tons Methane													
Energy Sources													
Coal Mining	4.25	4.10	4.05	3.44	3.51	3.66	3.19	3.50	3.28	3.12	2.98	2.96	2.86
Natural Gas Systems	5.60	5.83	5.89	5.88	5.89	5.98	6.00	6.01	6.02	6.19	6.41	6.38	6.47
Petroleum Systems	1.30	1.31	1.27	1.21	1.18	1.17	1.15	1.14	1.11	1.05	1.03	1.03	1.02
Stationary Combustion	0.56	0.59	0.62	0.54	0.53	0.58	0.58	0.44	0.39	0.42	0.44	0.41	0.36
Mobile Sources	0.25	0.24	0.24	0.24	0.24	0.25	0.24	0.24	0.24	0.26	0.25	0.24	0.24
Total Energy Sources	**11.96**	**12.06**	**12.07**	**11.30**	**11.35**	**11.64**	**11.16**	**11.33**	**11.04**	**11.02**	**11.10**	**11.03**	**10.95**
Waste Management													
Landfills	11.01	10.86	10.77	10.58	10.27	9.87	9.37	8.80	8.25	7.91	7.87	7.58	6.94
Wastewater Treatment	0.58	0.58	0.59	0.60	0.60	0.61	0.61	0.62	0.63	0.63	0.65	0.66	0.67
Total Waste Management	**11.59**	**11.44**	**11.36**	**11.18**	**10.88**	**10.48**	**9.98**	**9.42**	**8.88**	**8.54**	**8.53**	**8.24**	**7.61**
Agricultural Sources													
Enteric Fermentation	5.22	5.19	5.29	5.24	5.34	5.42	5.31	5.19	5.11	5.11	5.06	5.00	5.00
Animal Waste	1.93	2.19	2.21	2.26	2.34	2.35	2.34	2.48	2.51	2.46	2.46	2.49	2.47
Rice Cultivation	0.40	0.40	0.45	0.41	0.48	0.44	0.41	0.45	0.47	0.50	0.45	0.47	0.46
Crop Residue Burning	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Agricultural Sources	**7.60**	**7.81**	**8.01**	**7.95**	**8.21**	**8.26**	**8.11**	**8.18**	**8.13**	**8.11**	**8.02**	**8.01**	**7.98**
Industrial Processes	**0.12**	**0.11**	**0.12**	**0.12**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.11**	**0.11**
Total	**31.27**	**31.43**	**31.55**	**30.55**	**30.57**	**30.51**	**29.39**	**29.05**	**28.19**	**27.81**	**27.77**	**27.40**	**26.65**
Million Metric Tons Carbon Dioxide Equivalent													
Energy Sources													
Coal Mining	97.68	94.24	93.24	79.03	80.83	84.18	73.46	80.39	75.55	71.67	68.44	68.11	65.67
Natural Gas Systems	128.91	134.00	135.51	135.21	135.48	137.61	138.04	138.24	138.39	142.29	147.36	146.85	148.85
Petroleum Systems	29.88	30.13	29.12	27.82	27.10	26.93	26.36	26.33	25.54	24.04	23.80	23.69	23.46
Stationary Combustion	12.97	13.60	14.28	12.34	12.12	13.33	13.35	10.06	9.07	9.63	10.05	9.47	8.30
Mobile Sources	5.65	5.41	5.43	5.56	5.61	5.78	5.58	5.49	5.48	5.93	5.66	5.58	5.53
Total Energy Sources	**275.09**	**277.39**	**277.57**	**259.95**	**261.14**	**267.82**	**256.78**	**260.51**	**254.03**	**253.55**	**255.31**	**253.71**	**251.82**
Waste Management													
Landfills	253.26	249.81	247.76	243.41	236.31	227.05	215.40	202.34	189.85	182.01	181.11	174.41	159.66
Wastewater Treatment	13.27	13.42	13.57	13.71	13.85	13.98	14.11	14.25	14.38	14.51	15.01	15.15	15.34
Total Waste Management	**266.53**	**263.22**	**261.33**	**257.13**	**250.16**	**241.03**	**229.51**	**216.58**	**204.23**	**196.51**	**196.12**	**189.57**	**175.00**
Agricultural Sources													
Enteric Fermentation	119.96	119.27	121.75	120.48	122.80	124.67	122.21	119.45	117.44	117.42	116.40	115.08	115.05
Animal Waste	44.49	50.38	50.93	51.95	53.92	54.07	53.83	57.15	57.78	56.56	56.67	57.32	56.78
Rice Cultivation	9.30	9.09	10.31	9.40	10.95	10.22	9.42	10.32	10.71	11.47	10.24	10.78	10.54
Crop Residue Burning	1.04	0.97	1.14	0.94	1.20	0.97	1.12	1.12	1.14	1.10	1.15	1.12	1.07
Total Agricultural Sources	**174.79**	**179.71**	**184.13**	**182.76**	**188.87**	**189.93**	**186.58**	**188.05**	**187.08**	**186.55**	**184.45**	**184.30**	**183.44**
Industrial Processes	**2.70**	**2.55**	**2.69**	**2.85**	**2.97**	**3.04**	**3.08**	**3.09**	**3.05**	**3.07**	**2.93**	**2.59**	**2.58**
Total	**719.10**	**722.87**	**725.72**	**702.69**	**703.15**	**701.83**	**675.94**	**668.24**	**648.40**	**639.69**	**638.81**	**630.16**	**612.84**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter. Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 4.83-4.84, web site www.ipcc.ch/pub/guide.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (Washington, DC, various years), web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissions.html.

Table 14. U.S. Methane Emissions from Coal Mining and Post-Mining Activities, 1990-2002

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Million Metric Tons Methane													
Surface Mining													
Mining	0.43	0.42	0.42	0.42	0.45	0.45	0.46	0.47	0.49	0.50	0.49	0.53	0.53
Post-Mining	0.68	0.65	0.65	0.56	0.64	0.64	0.66	0.67	0.67	0.63	0.61	0.62	0.57
Underground Mining													
Ventilation (Gassy Mines)	2.13	2.04	2.10	1.82	1.85	1.91	1.71	1.79	1.80	1.76	1.67	1.62	1.51
Ventilation (Nongassy Mines)	0.03	0.03	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03
Degasification Systems	1.26	1.23	1.17	1.05	1.06	1.21	1.02	1.06	0.95	0.79	0.87	0.93	1.03
Post-Mining	0.64	0.61	0.61	0.53	0.60	0.60	0.62	0.63	0.63	0.59	0.56	0.57	0.52
Methane Recovery for Energy (-)	0.26	0.27	0.31	0.44	0.51	0.57	0.69	0.54	0.67	0.61	0.70	0.76	0.81
Net Emissions	**4.25**	**4.10**	**4.05**	**3.44**	**3.51**	**3.66**	**3.19**	**3.50**	**3.28**	**3.12**	**2.98**	**2.96**	**2.86**
Million Metric Tons Carbon Dioxide Equivalent													
Surface Mining													
Mining	9.82	9.57	9.59	9.66	10.31	10.34	10.63	10.87	11.37	11.51	11.37	12.11	12.11
Post-Mining	0.85	0.83	0.83	0.84	0.90	0.90	0.92	0.95	0.99	1.00	0.99	1.05	1.05
Underground Mining													
Ventilation (Gassy Mines)	48.91	46.96	48.32	41.86	42.50	43.86	39.32	41.22	41.51	40.55	38.31	37.18	34.70
Ventilation (Nongassy Mines)	0.62	0.59	0.54	0.55	0.65	0.80	0.85	0.84	0.94	0.92	0.87	0.84	0.79
Degasification Systems	28.88	28.35	27.02	24.05	24.44	27.76	23.46	24.44	21.80	18.08	20.00	21.33	23.67
Post-Mining	14.69	14.09	14.09	12.15	13.81	13.71	14.19	14.56	14.46	13.56	12.93	13.17	12.06
Methane Recovery for Energy (-)	6.09	6.15	7.15	10.09	11.78	13.19	15.91	12.49	15.51	13.96	16.03	17.57	18.71
Net Emissions	**97.68**	**94.24**	**93.24**	**79.03**	**80.83**	**84.18**	**73.46**	**80.39**	**75.55**	**71.67**	**68.44**	**68.11**	**65.67**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: Coal production numbers from Energy Information Administration, *Coal Production*, DOE/EIA-0118 (Washington, DC, various years), and *Coal Industry Annual*, DOE/EIA-0584 (Washington, DC, various years). Methane recovery rates from U.S. Environmental Protection Agency, Office of Air and Radiation, Non-CO_2 Gases and Sequestration Branch, Coalbed Methane Outreach Program. Ventilation data for 1985, 1988, and 1990 provided by G. Finfinger, U.S. Department of the Interior, Bureau of Mines, Pittsburgh Research Center. Ventilation data for all other years provided by U.S. Environmental Protection Agency, Office of Air and Radiation, Non-CO_2 Gases and Sequestration Branch, Coalbed Methane Outreach Program.

Table 15. U.S. Methane Emissions from Natural Gas Systems, 1990-2002

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Million Metric Tons Methane													
Production	1.47	1.49	1.49	1.51	1.55	1.57	1.58	1.65	1.67	1.62	1.73	1.82	1.80
Gas Processing	0.65	0.71	0.70	0.71	0.71	0.72	0.73	0.71	0.69	0.70	0.71	0.70	0.64
Transmission and Storage	2.10	2.21	2.23	2.15	2.11	2.14	2.11	2.05	2.00	2.06	2.15	2.00	2.16
Distribution	1.39	1.42	1.47	1.51	1.53	1.55	1.58	1.59	1.66	1.80	1.81	1.87	1.87
Total	**5.60**	**5.83**	**5.89**	**5.88**	**5.89**	**5.98**	**6.00**	**6.01**	**6.02**	**6.19**	**6.41**	**6.38**	**6.47**
Million Metric Tons Carbon Dioxide Equivalent													
Production	33.77	34.27	34.32	34.80	35.63	36.06	36.28	37.98	38.43	37.32	39.90	41.75	41.47
Gas Processing	14.85	16.23	16.06	16.36	16.25	16.50	16.90	16.39	15.97	16.13	16.43	16.01	14.73
Transmission and Storage	48.26	50.94	51.40	49.40	48.51	49.33	48.53	47.18	45.89	47.36	49.43	46.01	49.57
Distribution	32.03	32.56	33.73	34.65	35.08	35.73	36.32	36.68	38.10	41.49	41.60	43.08	43.08
Total	**128.91**	**134.00**	**135.51**	**135.21**	**135.48**	**137.61**	**138.04**	**138.24**	**138.39**	**142.29**	**147.36**	**146.85**	**148.85**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: National Risk Management Research Laboratory, *Methane Emissions From the Natural Gas Industry*, Vol. 2, Technical Report, GRI-94/0257.1 and EPA-600-R-96-08 (Research Triangle Park, NC, June 1996), Appendix A; American Gas Association, *Gas Facts* (various years); Energy Information Administration, *Natural Gas Annual,* DOE/EIA-0131 (various years); Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2003/07) (Washington, DC, July 2003); Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340 (Washington, DC, various years).

Table 16. U.S. Methane Emissions from Petroleum Systems, 1990-2002

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Million Metric Tons Methane													
Refineries	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Exploration and Production	1.26	1.27	1.23	1.17	1.14	1.13	1.11	1.11	1.07	1.01	1.00	0.99	0.98
Crude Oil Transportation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**1.30**	**1.31**	**1.27**	**1.21**	**1.18**	**1.17**	**1.15**	**1.14**	**1.11**	**1.05**	**1.03**	**1.03**	**1.02**
Million Metric Tons Carbon Dioxide Equivalent													
Refineries	0.57	0.56	0.55	0.57	0.58	0.58	0.59	0.61	0.62	0.62	0.64	0.62	0.62
Exploration and Production	29.01	29.28	28.29	26.97	26.26	26.08	25.50	25.45	24.66	23.17	22.93	22.85	22.62
Crude Oil Transportation	0.30	0.29	0.28	0.28	0.27	0.27	0.27	0.27	0.26	0.24	0.23	0.22	0.22
Total	**29.88**	**30.13**	**29.12**	**27.82**	**27.10**	**26.93**	**26.36**	**26.33**	**25.54**	**24.04**	**23.80**	**23.69**	**23.46**

*Less than 0.05 million metric tons of methane.

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: U.S. Environmental Protection Agency, Office of Air and Radiation, *Draft Estimates of Methane Emissions from the U.S. Oil Industry* (Draft Report, Washington, DC); Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340 (Washington, DC, various years); and *Oil and Gas Journal*, Worldwide Refining Issue and Pipeline Economics Issue (various years).

Table 17. U.S. Methane Emissions from Stationary Combustion Sources, 1990-2002

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
	Thousand Metric Tons Methane												
Residential													
Coal	*	*	*	*	*	*	*	*	*	*	*	*	*
Fuel Oil[a]	5	5	5	5	5	5	5	4	4	4	5	5	5
Natural Gas	4	5	5	5	5	5	5	5	4	5	5	5	5
LPG	*	*	*	*	*	*	1	1	1	1	1	1	1
Wood	512	541	569	483	474	526	525	382	341	365	382	359	309
Total	**522**	**550**	**579**	**493**	**484**	**535**	**535**	**392**	**350**	**374**	**392**	**369**	**319**
Commercial													
Coal	1	1	1	1	1	1	1	1	1	1	1	1	1
Fuel Oil[a]	1	1	1	1	1	1	1	*	*	*	*	*	*
Natural Gas	3	3	3	3	3	4	4	4	4	4	4	4	4
LPG	*	*	*	*	*	*	*	*	*	*	*	*	*
Wood	*	*	*	*	*	*	*	*	*	*	*	*	*
Total	**5**	**5**	**5**	**5**	**5**	**5**	**6**	**6**	**5**	**5**	**5**	**5**	**5**
Industrial													
Coal	7	6	6	6	6	6	6	6	5	5	5	5	5
Fuel Oil[a]	1	1	1	1	1	1	1	1	1	1	1	1	1
Natural Gas	11	12	12	12	12	13	13	13	13	13	13	12	11
LPG	2	2	3	2	3	3	3	3	3	3	3	3	3
Wood	4	4	4	4	4	4	5	5	4	4	4	4	4
Total	**25**	**25**	**26**	**26**	**27**	**27**	**28**	**28**	**26**	**26**	**26**	**25**	**24**
Electric Power													
Coal	10	10	10	10	10	11	11	11	12	12	12	12	12
Fuel Oil[a]	1	1	1	1	1	*	*	1	1	1	1	1	*
Natural Gas	*	*	*	*	*	*	*	*	*	*	1	1	1
Wood	*	*	*	*	*	*	*	*	*	*	*	*	*
Total	**11**	**11**	**11**	**11**	**11**	**11**	**12**	**12**	**13**	**13**	**13**	**13**	**13**
Total All Fuels													
Coal	18	17	17	18	18	18	18	18	18	18	18	18	18
Fuel Oil[a]	8	7	7	8	7	7	7	6	6	6	7	6	6
Natural Gas	19	20	20	21	21	22	23	23	22	21	22	21	21
LPG	3	3	3	3	3	3	4	4	3	4	4	4	4
Wood	516	544	573	487	478	530	529	387	346	370	386	363	313
Total	**564**	**591**	**621**	**536**	**527**	**579**	**580**	**437**	**394**	**419**	**437**	**412**	**361**

*Less than 500 metric tons of methane.
P = preliminary data.
[a]Fuel oil use in the residential sector consists of distillate fuel only. In the other sectors it includes both distillate and residual fuel oil.
See notes and sources at end of table.

Table 17. U.S. Methane Emissions from Stationary Combustion Sources, 1990-2002 (Continued)

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
	Thousand Metric Tons Carbon Dioxide Equivalent												
Residential													
Coal	*	*	*	*	*	*	*	*	*	*	*	*	*
Fuel Oil[a]	113	108	113	113	111	105	107	101	89	96	105	105	104
Natural Gas	100	104	107	112	110	110	119	113	103	107	113	109	112
LPG	10	10	10	11	11	11	13	12	12	14	15	14	15
Wood	11,783	12,432	13,081	11,114	10,891	12,087	12,067	8,782	7,849	8,396	8,782	8,254	7,098
Total	**12,006**	**12,654**	**13,312**	**11,350**	**11,123**	**12,313**	**12,306**	**9,008**	**8,053**	**8,613**	**9,014**	**8,482**	**7,329**
Commercial													
Coal	30	27	27	28	27	27	28	30	21	24	21	22	22
Fuel Oil[a]	16	15	14	13	13	12	12	10	9	9	10	10	10
Natural Gas	72	75	77	78	79	82	86	87	82	83	87	83	85
LPG	2	2	2	2	2	2	2	2	2	3	3	3	3
Wood	3	3	3	3	3	3	3	3	3	4	4	3	3
Total	**122**	**122**	**123**	**124**	**124**	**126**	**132**	**133**	**118**	**122**	**125**	**120**	**123**
Industrial													
Coal	151	142	137	136	137	136	133	130	122	119	121	124	116
Fuel Oil[a]	32	27	30	34	32	27	27	24	20	18	21	18	20
Natural Gas	263	266	277	282	283	298	307	308	303	291	295	269	264
LPG	51	55	59	57	63	64	66	68	65	71	72	65	69
Wood	89	87	90	91	97	102	104	107	99	100	101	89	93
Total	**585**	**577**	**593**	**600**	**613**	**626**	**637**	**637**	**608**	**599**	**609**	**565**	**561**
Electric Power													
Coal	225	226	229	239	240	242	256	262	267	268	281	273	277
Fuel Oil[a]	19	18	14	16	14	9	10	12	17	16	14	16	*
Natural Gas	7	8	8	8	9	10	9	9	10	11	12	12	13
Wood	1	1	1	*	*	*	*	*	*	*	*	*	*
Total	252	251	251	262	262	261	274	283	294	294	306	301	290
Total All Fuels													
Coal	406	395	393	403	404	405	417	423	410	410	422	419	416
Fuel Oil[a]	180	167	172	175	171	152	156	147	135	138	150	149	131
Natural Gas	442	452	468	480	481	500	521	518	499	492	507	472	473
LPG	62	68	71	69	76	77	81	82	78	88	90	82	87
Wood	11,875	12,522	13,175	11,208	10,991	12,192	12,174	8,891	7,951	8,499	8,886	8,346	7,194
Total	**12,965**	**13,604**	**14,279**	**12,336**	**12,123**	**13,326**	**13,348**	**10,061**	**9,073**	**9,628**	**10,054**	**9,468**	**8,302**

*Less than 500 metric tons carbon dioxide equivalent.
P = preliminary data.
[a]Fuel oil use in the residential sector consists of distillate fuel only. In the other sectors it includes both distillate and residual fuel oil.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.
Sources: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Compilation of Air Pollutant Emission Factors*, AP-42, web site www.epa.gov/ttn/chief; Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), web site www.ipcc.ch/pub/guide.htm; and Energy Information Administration, *State Energy Data Report*, DOE/EIA-0214 (Washington, DC, various years), *Monthly Energy Review*, DOE/EIA-0035(2003/07) (Washington, DC, July 2003), and *Annual Energy Review*, DOE/EIA-0384(2001) (Washington, DC, various years).

Table 18. U.S. Methane Emissions from Mobile Sources, 1990-2002

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Thousand Metric Tons Methane													
Motor Vehicles													
Passenger Cars	142	132	131	126	117	109	107	105	105	106	100	99	99
Buses	1	1	1	1	1	1	1	1	1	1	1	1	1
Motorcycles	4	4	4	4	4	4	4	4	4	4	4	4	4
Light-Duty Trucks	64	64	64	75	86	100	93	92	92	108	101	101	100
Other Trucks	12	12	12	13	14	14	15	15	16	17	17	17	16
Total	**223**	**212**	**212**	**220**	**222**	**229**	**220**	**217**	**218**	**236**	**223**	**222**	**221**
Other Transport	23	23	24	22	22	23	23	21	21	21	23	21	20
Total Transport	**246**	**235**	**236**	**242**	**244**	**251**	**242**	**239**	**238**	**258**	**246**	**243**	**240**
Thousand Metric Tons Carbon Dioxide Equivalent													
Motor Vehicles													
Passenger Cars	3,265	3,035	3,019	2,901	2,701	2,515	2,467	2,406	2,404	2,427	2,310	2,288	2,272
Buses	21	21	21	23	24	24	24	25	26	28	28	26	29
Motorcycles	92	88	92	95	99	94	96	97	99	101	101	92	98
Light-Duty Trucks	1,474	1,463	1,464	1,735	1,967	2,292	2,133	2,111	2,113	2,495	2,317	2,319	2,310
Other Trucks	277	279	283	296	315	330	339	354	363	381	380	384	363
Total	**5,129**	**4,887**	**4,879**	**5,049**	**5,105**	**5,256**	**5,058**	**4,993**	**5,005**	**5,432**	**5,137**	**5,110**	**5,072**
Other Transport	525	526	548	507	502	521	518	494	473	494	519	474	454
Total Transport	**5,654**	**5,412**	**5,427**	**5,556**	**5,607**	**5,777**	**5,576**	**5,488**	**5,478**	**5,926**	**5,655**	**5,584**	**5,527**

P = preliminary data.

Note: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002).

Sources: Calculations based on vehicle miles traveled from U.S. Department of Transportation, *Federal Highway Statistics*, various years, Table VM-1. Vehicle emissions coefficients from Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 1.65-1.75, web site www.ipcc.ch/pub/guide.htm. Distribution of passenger car and light duty truck fleet model years for 1983, 1985, 1988, 1991, 1994, and 1997 according to data in the Energy Information Administration's "Residential Transportation Energy Consumption Surveys" for those years. Distribution for passenger cars and light-duty trucks in other years computed by interpolation. Distribution of bus and other truck fleet according to model year computed assuming 10-percent attrition per annum of pre-1983 fleet for each year after 1984. Fuel consumption for other transport from Energy Information Administration, *Fuel Oil and Kerosene Sales*, DOE/EIA-0535 (Washington, DC, various years), and *Petroleum Supply Annual*, DOE/EIA-0340 (Washington, DC, various years).

Table 19. U.S. Methane Emissions from Landfills, 1990-2002

Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Million Metric Tons Methane													
Gross Emissions from Landfills	12.20	12.32	12.44	12.50	12.56	12.61	12.61	12.59	12.57	12.58	12.72	12.85	12.81
Methane Recovered for Energy (-)	0.73	0.77	0.83	0.89	1.03	1.06	1.22	1.45	1.75	2.00	2.19	2.40	3.00
Methane Assumed Flared (-)	0.46	0.69	0.84	1.02	1.26	1.67	2.02	2.34	2.57	2.66	2.66	2.87	2.87
Net Emissions	**11.01**	**10.86**	**10.77**	**10.58**	**10.27**	**9.87**	**9.37**	**8.80**	**8.25**	**7.91**	**7.87**	**7.58**	**6.94**
Million Metric Tons Carbon Dioxide Equivalent													
Gross Emissions from Landfills	280.64	283.41	286.14	287.49	288.86	289.92	290.06	289.51	289.21	289.26	292.62	295.46	294.67
Methane Recovered for Energy (-)	16.84	17.76	19.00	20.52	23.64	24.47	28.06	33.40	40.30	46.05	50.30	55.11	69.07
Methane Assumed Flared (-)	10.53	15.80	19.34	23.53	28.87	38.36	46.55	53.77	59.06	61.20	61.20	65.94	65.94
Net Emissions	**253.26**	**249.81**	**247.76**	**243.41**	**236.31**	**227.05**	**215.40**	**202.34**	**189.85**	**182.01**	**181.11**	**174.41**	**159.66**

P = preliminary data.

Note: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002).

Sources: Municipal solid waste landfilled from "Nationwide Survey: The State of Garbage in America," *Biocycle* (various years) for years before 2001. Waste generation and waste landfilled for 2001 and 2002 estimated on the basis of annual economic growth. Emissions calculations based on S.A. Thorneloe et al., "Estimate of Methane Emissions from U.S. Landfills," Prepared for the U.S. Environmental Protection Agency, Office of Research and Development (April 1994), and D. Augenstein, "The Greenhouse Effect and U.S. Landfill Methane," *Global Environmental Change* (December 1992), pp. 311-328. Methane recovered and flared from U.S. Environmental Protection Agency, Office of Air and Radiation, Non-CO2 Gases and Sequestration Branch, Landfill Methane Outreach Program, web site www.epa.gov/lmop/.

Table 20. U.S. Methane Emissions from Enteric Fermentation in Domesticated Animals, 1990-2002

Animal Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Million Metric Tons Methane													
Cattle	4.94	4.91	5.02	4.97	5.07	5.16	5.06	4.94	4.85	4.86	4.82	4.76	4.76
Sheep	0.08	0.09	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Pigs	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.05
Goats	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Horses	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10
Total	**5.22**	**5.19**	**5.29**	**5.24**	**5.34**	**5.42**	**5.31**	**5.19**	**5.11**	**5.11**	**5.06**	**5.00**	**5.00**
Million Metric Tons Carbon Dioxide Equivalent													
Cattle	113.68	112.90	115.41	114.25	116.59	118.67	116.37	113.54	111.53	111.75	110.75	109.38	109.43
Sheep	1.88	1.99	2.01	2.00	2.06	2.01	1.94	2.11	2.15	2.05	2.04	2.06	2.05
Pigs	2.09	2.06	1.99	1.88	1.81	1.65	1.56	1.48	1.44	1.33	1.29	1.28	1.23
Goats	0.22	0.21	0.23	0.23	0.23	0.21	0.22	0.19	0.16	0.16	0.15	0.16	0.14
Horses	2.10	2.11	2.12	2.12	2.12	2.12	2.13	2.14	2.17	2.14	2.17	2.19	2.19
Total	**119.96**	**119.27**	**121.75**	**120.48**	**122.80**	**124.67**	**122.21**	**119.45**	**117.44**	**117.42**	**116.40**	**115.08**	**115.05**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: Cattle, sheep, and pig population data provided by the U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock, Dairy and Poultry Service. Goat and horse population figures extrapolated from U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture*, 1982, 1987, 1992, and 1997. Emissions calculations based on U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2001*, EPA-430-R-03-004 (Washington, DC, April 2003), web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html; and P.J. Crutzen, I. Aselmann, and W.S. Seiler, "Methane Production by Domestic Animals, Wild Ruminants, Other Herbivorous Fauna, and Humans," *Tellus*, Vol. 38B (1986), pp. 271-284.

Table 21. U.S. Methane Emissions from the Solid Waste of Domesticated Animals, 1990-2002

Animal Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Thousand Metric Tons Methane													
Cattle													
Beef Cattle	176	194	198	202	207	210	209	204	200	198	195	194	194
Dairy Cattle	553	556	559	594	631	662	695	732	738	743	758	772	766
Swine													
Market Swine	879	1,089	1,103	1,097	1,139	1,111	1,070	1,171	1,199	1,147	1,142	1,157	1,143
Breeding Swine	152	176	173	174	170	165	160	169	163	152	153	151	146
Poultry													
Layers	72	73	75	76	78	79	80	81	83	86	88	89	90
Broilers	69	73	76	85	90	94	96	99	100	103	98	99	101
Other Animals													
Sheep	5	2	2	2	2	2	1	1	1	1	1	1	1
Goats	1	1	1	1	1	1	1	1	1	1	1	1	1
Horses	27	27	27	28	28	28	28	28	28	28	29	27	27
Total	**1,934**	**2,191**	**2,214**	**2,259**	**2,344**	**2,351**	**2,340**	**2,485**	**2,512**	**2,459**	**2,464**	**2,492**	**2,469**
Thousand Metric Tons Carbon Dioxide Equivalent													
Cattle													
Beef Cattle	4,040	4,458	4,552	4,636	4,760	4,838	4,814	4,682	4,592	4,547	4,496	4,470	4,454
Dairy Cattle	12,717	12,790	12,849	13,665	14,502	15,236	15,992	16,829	16,970	17,092	17,430	17,746	17,614
Swine													
Market Swine	20,217	25,045	25,379	25,220	26,196	25,547	24,610	26,922	27,579	26,380	26,261	26,621	26,292
Breeding Swine	3,502	4,045	3,978	4,010	3,916	3,788	3,681	3,893	3,739	3,488	3,508	3,474	3,364
Poultry													
Layers	1,663	1,682	1,726	1,755	1,794	1,814	1,838	1,871	1,913	1,979	2,016	2,052	2,076
Broilers	1,590	1,671	1,749	1,966	2,059	2,158	2,199	2,266	2,298	2,372	2,255	2,284	2,313
Other Animals													
Sheep	115	44	42	40	39	35	33	31	31	28	28	27	26
Goats	20	21	21	20	19	18	17	17	16	15	14	13	13
Horses	625	628	631	633	636	638	641	643	646	654	657	628	630
Total	**44,491**	**50,383**	**50,927**	**51,946**	**53,920**	**54,073**	**53,826**	**57,154**	**57,783**	**56,556**	**56,665**	**57,316**	**56,782**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: Population data for horses and goats extrapolated from U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture*, 1982, 1987, 1992, and 1997. Population data for all other animals from U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock, Dairy and Poultry Branch. Typical animal sizes from U.S. Environmental Protection Agency, Office of Air and Radiation, *Anthropogenic Methane Emissions in the United States: Estimates for 1990, Report to Congress* (Washington, DC, April 1993), p. 6-8; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2001*, EPA-430-R-03-004 (Washington, DC, April 2003), Table M-2, web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html. Cattle sizes adjusted by annual slaughter weight from U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock, Dairy and Poultry Branch. Maximum methane production, and waste management systems used from L.M. Safley, M.E. Casada, et al., *Global Methane Emissions from Livestock and Poultry Manure* (Washington, DC: U.S. Environmental Protection Agency, February 1992), pp. 24-27; U.S. Environmental Protection Agency, Cost Methodology Report for Beef and Dairy Animal Feeding Operations, EPA-821-R-01-019 (Washington, DC, January 2001), pp.1-13–1-14; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2001*, EPA-430-R-03-004 (Washington, DC, April 2003), Table M-2. General methane conversion factors from Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), p. 4.25, web site www.ipcc.ch/pub/guide.htm. State methane conversion factors for dairy cattle from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1998*, EPA-236-R-00-001 (Washington, DC, April 2001); and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2001*, EPA-430-R-03-004 (Washington, DC, April 2003), Table M-4.

Table 22. U.S. Methane Emissions from Industrial Processes, 1990-2002

(Thousand Metric Tons Methane)

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	P2002
Thousand Metric Tons Methane													
Chemical Production													
Ethylene	17	18	19	19	20	21	22	23	23	25	23	20	21
Ethylene Dichloride	3	2	3	3	3	3	3	4	4	4	4	3	3
Styrene	15	15	16	18	20	21	22	21	21	22	20	16	18
Methanol	8	8	7	10	10	10	11	12	11	11	9	9	6
Carbon Black	14	13	15	16	16	17	17	17	18	18	17	16	17
Total	**56**	**57**	**60**	**66**	**70**	**72**	**75**	**77**	**77**	**80**	**72**	**64**	**66**
Iron and Steel Production													
Coke[a]	11	9	9	9	8	9	8	7	7	6	7	6	6
Sinter	6	5	6	6	6	6	6	6	5	6	5	5	5
Pig Iron	45	40	43	43	44	46	44	45	43	42	43	38	36
Total	**62**	**54**	**57**	**58**	**59**	**61**	**59**	**58**	**56**	**54**	**55**	**48**	**46**
Total Industrial Processes	**117**	**111**	**117**	**124**	**129**	**132**	**134**	**134**	**133**	**133**	**127**	**112**	**112**
Thousand Metric Tons Carbon Dioxide Equivalent													
Chemical Production													
Ethylene	380	417	427	430	465	488	511	531	540	578	521	470	493
Ethylene Dichloride	58	57	63	75	78	72	79	84	82	91	82	78	78
Styrene	335	339	376	420	470	475	496	476	477	499	452	357	415
Methanol	174	182	169	220	226	225	245	267	262	254	218	211	137
Carbon Black	331	310	345	367	378	386	395	402	407	415	384	363	386
Total	**1,277**	**1,304**	**1,380**	**1,512**	**1,616**	**1,646**	**1,726**	**1,760**	**1,767**	**1,837**	**1,658**	**1,479**	**1,509**
Iron and Steel Production													
Coke[a]	251	206	202	199	191	201	193	172	163	148	155	130	132
Sinter	141	122	132	143	140	144	136	132	125	127	124	106	104
Pig Iron	1,028	913	981	997	1,022	1,053	1,023	1,027	998	958	991	872	833
Total	**1,420**	**1,241**	**1,314**	**1,339**	**1,353**	**1,399**	**1,352**	**1,330**	**1,286**	**1,233**	**1,271**	**1,108**	**1,068**
Total Industrial Processes	**2,697**	**2,545**	**2,694**	**2,851**	**2,969**	**3,044**	**3,078**	**3,090**	**3,053**	**3,070**	**2,928**	**2,587**	**2,577**

[a]Based on total U.S. production of metallurgical coke, including non-iron and steel uses.

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002). Totals may not equal sum of components due to independent rounding.

Sources: American Iron and Steel Institute, *Annual Statistical Report* (Washington, DC, various years); American Chemical Council (formerly the Chemical Manufacturers Association), *U.S. Chemical Industry Statistical Handbook* (Washington, DC, various years); and Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), p. 2.23, web site www.ipcc/pub/guide.htm.